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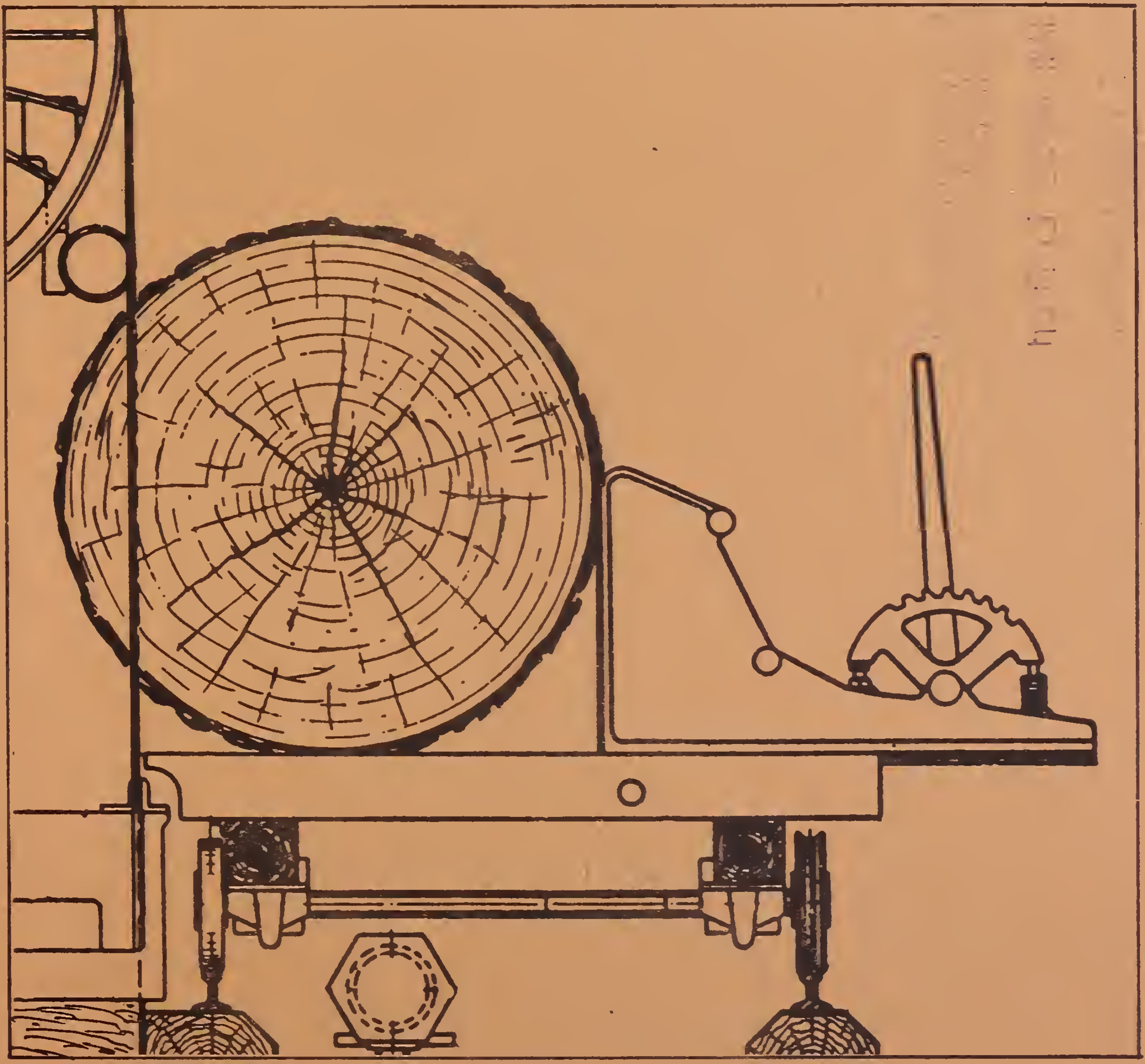
AN ECONOMIC EVALUATION OF THE SOUTH'S 1977 SAWMILL IMPROVEMENT PROGRAM



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AN ECONOMIC EVALUATION OF THE SOUTH'S 1977 SAWMILL IMPROVEMENT PROGRAM

by

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CONTENTS

Introduction 1

Study Methods 2

  Analysis Period 2

  Data Collection 3

    Data on Cost Savings (Benefits) 3

    Cost Data 4

  Data Analysis 6

    Predicting Changes in the LRF 6

    Where Do Cost Savings Occur? -- An Important Assumption 8

    Benefits and Costs from Sawmill Improvement 9

    Delivered Log Prices 11

Results and Discussion 14

  Diminishing Returns Over Time 14

  Best and Worst Candidates for Improvement 15

  Stretching Timber Supply 16

  Cost Efficiency 16

Summary 20

Appendixes 21

  A. Average Price for Delivered Southern Yellow Pine Logs, 1977 22

  B. Benefits and Costs of Sawmill Improvement, by Study, FY 1977 25

INTRODUCTION

The Sawmill Improvement Program (SIP) was launched by the USDA Forest Service on May 7, 1973, with the goal of extending the Nation's softwood timber supply by improving conversion efficiency in sawmills. SIP mill analyses focus on three objectives:

1. To inform mill operators of their present Lumber Recovery Factor (LRF). LRF is a convenient measure of conversion efficiency. It is the ratio of nominal board feet of rough green lumber output to cubic feet of log input.

2. To inform mill owners of their potential LRF with improved quality control.

3. To inform mill owners of the theoretical maximum LRF possible as a result of major equipment changes and additions.

By increasing the LRF, a mill can produce the same amount of lumber from fewer logs.

SIP is a cooperatively funded State and Federal effort. All of the Southern States participate in it. Indeed, the South's role in SIP has been significant. As of December 31, 1978, the majority (57 percent) of all the mills studied were located south of the Mason-Dixon line.

Mill participation in SIP is on a voluntary basis. SIP studies are conducted by State utilization foresters who work with the cooperating mills to collect relevant data. This primary data is then processed by the Forest Service at the Forest Products Laboratory in Madison, Wisconsin, where analyses are made on the University of Wisconsin computer. Results are forwarded to the State forestry agencies for presentation to the mill cooperators. Suggestions for improvements are included in the utilization forester's report to the mill. Often, additional studies are made to followup on progress and measure actual changes in the LRF.

This study focused on assessing the cost efficiency of the Sawmill Improvement Program in the South. The analysis is accomplished by first developing a model to predict changes over time in conversion efficiency following a SIP study. Then, this model is applied to all the original SIP studies conducted during a specific period, and an estimate of the cost savings (benefits) brought about by the study is made. Next, benefits are compared to costs of conducting the studies, and conclusions drawn as to the efficiency of the program and whether or not the goal of extending timber supply is being met.

STUDY METHODS

ANALYSIS PERIOD

The first step was to choose a time period for the analysis. Federal Fiscal Year 1977 was selected. At the beginning of the study, this was the most recently completed year. Also, by FY 1977, all the Southern States had been participating long enough for the program to pass the shakedown phase and to run smoothly.

DATA COLLECTION

Data on Cost Savings (Benefits)

The SIP Digest is the primary source of the data used to predict cost savings and, hence, benefits of the SIP program. The Digest is a computerized data file maintained by the National Sawmill Assistance Program at Madison, Wisconsin. It contains an up-to-date list of pertinent data on all the SIP studies.

While the data on file is quite useful, there are limitations. The primary limitation is that data on some variables of particular interest to this study were never collected -- the program managers had no reason for doing so. Limitations notwithstanding, the SIP Digest remains the best available data source.

A 100 percent sample was taken from the SIP Digest of all the studies conducted in the South for which there were followup studies or restudies. After eliminating some studies because of inconsistencies in the data, 70 mill study-restudy combinations were accepted for analysis. This sample of 70 represents approximately 16 percent of all studies in the South during the life of the SIP program. The following are of particular interest:

- Actual LRF at time of original and restudies.
- Time period between original and followup study.
- Changes in LRF over the time period.
- Type of headrig (band or circle).
- Annual production.
- Changes in annual production over time period.

The data from the SIP Digest covers the wide range of mill responses to a SIP study: from mills that accepted the recommendations of a SIP study completely, to mills that rejected them entirely, and from those that made significant improvements to LRF, to those that suffered losses. It is likely that the losses were suffered from not implementing SIP study recommendations.

Data from the SIP Digest is used with the assumption that the sample of logs, sawing system, and manufacturing conditions for a SIP study/restudy combination represents a mill's overall, year-round operation for the year of the study or restudy. This assumption is probably not entirely valid for a given mill. However, the effects of any inaccuracies for a particular mill should average out over the entire sample of 70 mill study/restudy combinations.

Cost Data

Cost data were obtained from each of the Southern States conducting softwood SIP studies in FY 1977. They include Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas, and Virginia. No cost data were obtained from Kentucky and Tennessee. While these two States actively participate in the SIP program, they did not conduct any softwood SIP studies that year. The two States emphasized studies of hardwood mills because they have few softwood mills.

The data provided by the State forestry organizations were broken down by mill study. First, the number of person-hours for every forester, technician, and clerical worker directly involved in a particular study was estimated. This included all pre-study, study, and followup activities. Next, the number of person-hours for each individual was multiplied by the appropriate cost/hour rate to arrive at subtotal cost for the State personnel involved. Cost per hour included salary, fringe benefit, and overhead components. Transportation, meals, and lodging were then added to the personnel subtotal to arrive at the total State cost for the study.

Federal overhead costs directly attributable to the FY 1977 SIP program were twofold. The first group were those associated with the National Sawmill Assistance Program at the Forest Products Laboratory; the second were those attached to the Southeastern Area, State and Private Forestry's Sawmill Specialist position. No Federal, indirect administrative overhead costs were included.

National Sawmill Assistance Program costs were provided by Stanford J. Lunstrum, Program Manager. A cost per study was derived by prorating these costs against the total number of studies conducted nationally in FY 1977. Similarly, costs associated with the Southeastern Area's Sawmill Specialist position were prorated against the total number of studies conducted in the South in FY 1977.

Costs incurred by the mill in implementing the recommendations of a SIP study are not included in this analysis, although it would have been desirable to do so. In almost all instances these costs are unknown or unavailable, and no reliable means exists for estimating them. This omission is probably not that significant. Many utilization foresters believe the costs of implementation are slight or nonexistant for a mill. On the other hand, there are a few specific instances where mills have made significant capital investments to increase conversion efficiency.

DATA ANALYSIS

Predicting Changes in the LRF

What was desired in this analysis was a way of expressing the relationships between actual changes in LRF between studies, a dependent variable, and a set of independent variables including: type of headrig, time period between studies, original LRF, and annual production. The following model served to accomplish this objective:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + . . . + \beta_k X_k$$

where,

Y = the dependent variable

X_j = an independent variable

β_j = the regression coefficient for X_j

To fit the general model, the data from the SIP Digest for the 70 study-restudy combinations were used to obtain estimates of the regression coefficients by least squares. Several independent variables and data transformations were tried. Then, once the final model had been selected and the regression coefficients estimated, the fitted equation became predictive -- one which could be used to predict changes in LRF for the SIP studies conducted in FY 1977.

The equation that was finally selected for predicting percent change in LRF following an original SIP study is:

$$Y = 40.9255 - .8744X_1 + .3028X_2 - 6.7198X_3$$

where,

Y = percent change in LRF

X_1 = Number of years after the study

X_2 = Sawmill's Annual Production (MMBF)

X_3 = Original LRF

The regression equation was determined by an "F" test to be statistically significant at the .1 percent level. Regression coefficients for X_1 and X_2 are statistically significant at the 5 percent level, and the regression coefficient for X_3 is statistically significant at the 1 percent level. The coefficient of determination (R^2) for the regression equation is .36 indicating that while the equation is statistically significant, a fair amount of variation remains unexplained. Given the nature of the original data, this is not surprising, nor is it a cause for undue concern. The 95 percent confidence limits for the values predicted by the equation are perfectly adequate for the purpose at hand.

Note that the regression equation is for both band and circle mills. Differences between the two were not statistically significant, thus, a distinction between the two was not made in the final equation.

An attempt to use the above general model to predict changes in LRF following a restudy produced no meaningful relationships. Regression equations were not statistically significant, even though coefficients of determination (R^2) ran as high as .84. The reason for the lack of significance was that the number of observations was very limited: only six mills had had an original study followed by two restudies. Further attempts to identify relationships of this nature were abandoned, and cost efficiencies of restudies were not examined. Subsequent findings pertain only to original studies.

Where Do Cost Savings Occur? -- An Important Assumption

Improvements in a mill's LRF produce these benefits: 1) increased lumber production from the same amount of log input, or 2) reduced raw material requirements for the same lumber production.

Most sawmill specialists believe there is some limiting factor in the design and layout of all sawmills that restricts production (e.g., capacity of the dry kiln). Improving conversion efficiency (LRF) does not usually eliminate this factor. Thus, instead of producing more lumber, a mill would use less raw material if it increased the LRF. At least one case study bears this out.[1] This hypothesis is also supported by the finding that no correlation could be established between changes in LRF and changes in annual production for the 70 study-restudy combinations. Correlation coefficients were not statistically significant.

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[1] Wells, Wesley. 1978. Personal communication. Georgia Forestry Commission, Macon, Georgia.

Based on the above, the assumption was made in this analysis that annual cost savings associated with an improvement in LRF would be estimated according to the value of reduced sawlog requirements. Only the value of delivered logs was considered. Savings in carrying charges on a reduced log inventory and reduced handling costs were not included, therefore, the cost savings estimate was a conservative one.

Benefits and Costs from Sawmill Improvement

Using the prediction equation described above, percent change in LRF was calculated for four years for each of the 45 original studies conducted in the South during FY 1977. Four years was the maximum amount of elapsed time between an original study and a followup study for the data used in developing the prediction equation. The effects of sawmill improvement are undoubtedly felt for a longer period of time than this; however, predicted values beyond four years become increasingly unreliable. For an example of the expected percentage change in LRF for a typical sawmill, see table 1.

Table 1.--Percent Change in Lumber Recovery Factor

After an Initial SIP Study for a Typical Southern Sawmill

Number years after initial SIP study	Percent Change in LRF	
	Predicted value	95% confidence limits
1	+5.79	+2.49 to +9.08
2	+4.91	+2.26 to +7.56
3	+4.04	-.56 to +8.64
4	+3.17	-4.18 to +10.52

$$Y = 40.9255 - .8744X_1 + .3028X_2 - 6.7198X_3$$

where,

Y = Percent change in LRF

X_1 = Number of years after the study (1, 2, 3, and 4)

X_2 = Sawmill's annual production (20 MMBF)

X_3 = Original LRF (6.00)

The next step was to calculate changes in raw material requirements for each of the 4 years following the SIP study. Here, it was assumed that a mill's annual production would not change over the analysis period. Continuing with the sawmill example from table 1, the savings in cubic foot volume of logs for the first year after a SIP study are 183,000 ft^3 as follows:

Item	Original Conditions	Improved Conditions
Annual production	20 MMBF	20 MMBF
LRF	6.00	6.35 (5.79% increase)
Volume of logs	$\frac{20\text{ MMBF}}{6.00} = 3.333\text{ MMCF}$	$\frac{20\text{ MMBF}}{6.35} = 3.150\text{ MMCF}$
Cubic foot savings	3.333 MMCF -3.150 .183 MMCF = $\underline{\underline{183{,}000}}\text{ ft}^3$	

Dollar savings are obtained for the year by multiplying the volume saved times a price per unit of volume. If the price per MCF is $832, then the cost savings for the mill in this example are $152,256 (183 MCF x $832/MCF).

Delivered Log Prices

Price information was derived from Timber-Mart South -- the only regional timber price reporting system in the South. This publication divides each of the Southern States into three zones and reports monthly by zone on low, high, and average prices paid for delivered southern yellow pine logs, among other items.

The Timber-Mart South 1977 monthly reports were used to compute an average delivered log price for the year for each zone within a State. This simple average was obtained by summing the average monthly prices and dividing by 12. Because these prices are in dollars per thousand board feet (Scribner scale), they were converted to dollars per thousand cubic feet by assuming an average log scaling diameter of 9.8 inches (24.9 cm) and using a conversion factor of 5.55 board feet per cubic foot.[2] For example, $150/MBF (Scribner) times 5.55 MBF/1 MCF = $832/MCF.

Mill locations in Timber-Mart South zones were established by the State forest product utilization specialists for each of the FY 1977 SIP studies. The appropriate zone price was then used to calculate cost savings for a particular study. Constant prices were assumed for each of the 4 years of the analysis period. Prices used in this analysis can be found in Appendix A.

Once cost savings (benefits) had been estimated for each of the 4 years following a SIP study, their present value was calculated by discounting at 10 percent interest for the appropriate time period.[3] Costs were then totaled and subtracted from the present value of benefits to arrive at Net Present Value. A Benefit/Cost ratio was also calculated by dividing the present value of cost savings by the cost of the study. These computations were made for each of the 45 original SIP studies made in FY 1977. A continuation of the previous example illustrates the process (table 2).

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[2] Source: Reynolds, R.R. 1937. Factors for converting log and tree volumes and values from one common scale to another. U.S. Dept. Agric. For. Serv., Southeast. For. Exp. Stn., Asheville, N.C. Occ. paper 68. The weighted average scaling diameter for the 45 original SIP studies conducted in FY 1977 was 9.8 inches.

[3] A 10 percent discount rate is recommended by the Office of Management and Budget in O.M.B. Circular A-94 (Revised).

Table 2.--Calculating net present value and benefit/cost ratio for a SIP study

(1) Item	(2) Year	(3) Volume (MCF)	(4) Value ($)	(5) Discount factor (@ 10%)	(4 x 5) Present value ($)
Cost of SIP study					
State	0	-	641	1.0000	641
Federal	0	-	927	1.0000	927
Total			1,568		1,568
Raw material savings					
	1	183	152,256	.9091	138,416
	2	156	129,792	.8264	107,260
	3	129	107,328	.7513	80,636
	4	102	84,864	.6830	57,962
Total		570			384,274

NPV = $384,274 - $1,568 = $382,706

$$B/C = \frac{\$384,274}{\$1,568} = 245:1$$

Once the present value of benefits and costs had been estimated for each of the 45 SIP studies conducted in FY 1977, an average for the South was obtained by totaling the figures for the individual studies and dividing by 45. Costs and benefits for the individual studies are presented in Appendix B along with the Southwide averages.

RESULTS AND DISCUSSION

DIMINISHING RETURNS OVER TIME

The effects of sawmill improvement are felt immediately, but diminish with the passing of time. This is not surprising because equipment is subject to wear, there are turnovers in labor and supervisory personnel, and so on. The relationship between the percent change in LRF and time is quantified in the regression equation:

$$Y = 40.9255 - .8744X_1 + .3028X_2 - 6.7198X_3$$

where,

Y = Percent change in LRF

X_1 = Number of years after the study

X_2 = Sawmill's annual production (MMBF)

X_3 = Original LRF

The negative regression coefficient for X_1 tells us that the percent change in LRF (Y) will decrease as the number of years (X_1) is increased, assuming the other two independent variables are held constant. This relationship is also illustrated by the predicted values of table 1. There, the percent increase in LRF dropped from a high of 5.79 percent for the first year, to 3.17 percent at the end of 4 years. It appears that a followup SIP study would be in order 1 year after the original study; certainly, within 3 to 5 years.

BEST AND WORST CANDIDATES FOR IMPROVEMENT

The prediction equation also lends credence to what most utilization foresters already know intuitively -- the higher a mill's annual production and the lower its original LRF, the greater the opportunity for improving conversion efficiency. The regression coefficients for the X_2 and X_3 independent variables quantify this relationship, and the predicted values of Appendix B illustrate the point aptly. From Appendix B, it can be seen that the largest payoffs in raw material savings occur with mills that have a large annual production (25-50 million board feet) and a low LRF originally (less than 5.00). The worst payoffs (i.e., decreases in LRF) occur with small mills (less than 5 million board feet) that have a fairly high original LRF (greater than 6.00). The fact that LRF decreases instead of increases after a SIP study for these latter cases indicates the variability of the data used in developing the prediction equation more than the cause and effect relationship of a SIP study. Nonetheless, the general trend holds true: improvements in conversion efficiency at small mills with a high LRF are apt to be minimal.

From a practical standpoint, knowledge of annual production is useful in identifying candidates for sawmill improvement, original LRF is not. Estimating a sawmill's annual production before a SIP study is one thing; estimating the original LRF without the benefit of a study is quite another.

STRETCHING TIMBER SUPPLY

The total volume of logs saved over a 4-year period by the mills undertaking SIP studies in FY 1977 is estimated at 46.7 million ft^3 (Appendix B). This works out to an average 4-year savings per study of slightly more than a million cubic feet (1.038 MMCF). The total savings are enough to provide a 4-year supply of logs to seven new mills in the 10 MMBF annual production category:

$$\frac{46.7\ \text{MMCF}}{4\ \text{years}} = 11.68\ \text{MMCF/year}$$

$$11.68\ \text{MMCF} \times 6.00\ (\text{average LRF}) = 70.05\ \text{MMBF}$$

$$\frac{70.05\ \text{MMBF}}{10\ \text{MMBF/mill}} = 7\ \underline{\underline{\text{sawmills}}}$$

COST EFFICIENCY

Expenditures by the public in conducting SIP studies in the South in FY 1977 totaled $70,578 (Appendix B). The average cost per study was $1,568. These costs were distributed as follows: State - $28,863 or $641 per study; Federal - $41,715 or $927 per study. Approximately two-thirds of the Federal costs ($629 per study) were associated with the National Sawmill Assistance Program at Madison, Wisconsin, while the remaining one-third ($298 per study) was attached to the Southeastern Area's Sawmill Specialist position. As noted previously, private sector (sawmill) costs to conduct a SIP study and to implement the recommendations of a SIP study are unknown or unavailable. On the other hand, returns to the private sector are substantial.

The present value, at 10 percent interest, of the projected raw material savings of 46.7 million ft^3 for the 4 years following the FY 1977 SIP program is $30,692,092. Collectively, the sawmills studied in FY 1977 could have invested $30.7 million ($682,000 per mill) in sawmill improvement, had the investment returned in four years in the form of reduced log requirements, and earned a 10 percent rate of return on their investment. It is highly unlikely that expenditures in sawmill improvement by the mills approached $30.7 million in magnitude. Thus, the rate of return to the private sector should far exceed the 10 percent interest rate used in discounting.

Turning now to the expenditure of public monies, and assuming that 100 percent of the projected improvement in conversion efficiecy is attributable to SIP, the cost efficiency of the program appears striking. The average Net Present Value (NPV) and Benefit/Cost (B/C) ratio for the 45 SIP studies conducted in FY 1977 are:

$$\text{NPV} = \$682{,}046 - \$1{,}568 = \underline{\underline{\$680{,}478}}$$

$$\text{B/C} = \frac{\$682{,}046}{\$1{,}568} = \underline{\underline{435:1}}$$

However, attributing 100 percent of the cost savings to the SIP program is not realistic. Some improvements in conversion efficiency undoubtedly would have occurred without the program, and SIP study costs reflect only a portion -- albeit a probable large portion -- of the total cost of sawmill improvement. Consequently, a better assessment of the efficiency of the program can be made by including only those benefits that accrue directly from the SIP study costs. Use table 3 and make your own assumptions about the appropriate relative proportions. Surely, the most pessimistic observer would agree that a minimum of 1 percent of the cost savings are a direct result of the program. Given such pessimism, the program still exhibits a very respectful benefit/cost ratio of 4.4:1.

Table 3.--Benefit/cost ratios for the South's FY 1977 Sawmill Improvement Program, by percentage of cost savings attributable to the program

Percent cost savings attributable to SIP	Benefit/cost ratio
100	435:1
90	392:1
80	348:1
70	304:1
60	261:1
50	218:1
40	174:1
30	130:1
20	87:1
10	44:1
1	4.4:1

SUMMARY

The cost efficiency of the South's FY 1977 Sawmill Improvement Program was evaluated. Data on the cost of conducting mill studies were provided by State forestry organizations. To these were added the Federal overhead costs that directly support the program. The SIP Digest was the primary source of data on changes in conversion efficiency following a SIP study.

A prediction equation was generated to predict the percent change in Lumber Recovery Factor (LRF) following a SIP study from 1) the number of years after the study, 2) the mill's annual production, and 3) the mill's original LRF. Next, benefits (cost savings) were calculated from the predicted change in LRF and compared to costs using two economic criteria: net present value and benefit/cost ratio.

Study results show the Sawmill Improvement Program in the South for FY 1977 meets the goal of extending timber supply, and does so in a very cost efficient manner. A most pessimistic assumption, that only 1 percent of the predicted cost savings are a direct result of the program, yields a benefit/cost ratio of 4.4:1.

APPENDIXES

APPENDIX A

Average Price for Delivered

Southern Yellow Pine Logs - 1977

Source: *Timber-Mart South*

State and Zone	Average Price for 1977	
	$/MBF (Scribner)	$/MCF*
Alabama		
1	120	666
2	135	749
3	150	832
Arkansas		
1	158	877
2	138	766
3	-	-
Florida		
1	155	860
2	137	760
3	136	755

---

*$/MCF = $/MBF (Scribner) times 5.55 MBF/1 MCF. The 5.55 to 1 ratio was obtained from Reynolds, R.R. 1937. Factors for converting log and tree volumes and values from one common scale to another. U.S. Dept. Agric. For. Serv., Southeast. For. Exp. Stn., Occ. paper 68. An average log scaling diameter of 9.8 inches (24.9 cm) is assumed. This is the weighted average scaling diameter of the logs from the 45 studies conducted in FY 1977.

APPENDIX A (continued)

Source: *Timber-Mart South*

State and Zone	Average Price for 1977	
	$/MBF (Scribner)	$/MCF*
Georgia		
1	111	616
2	139	771
3	165	916
Louisiana		
1	152	844
2	-	-
3	154	855
Mississippi		
1	-	-
2	136	755
3	154	855
North Carolina		
1	101	561
2	138	766
3	158	877
South Carolina		
1	116	644
2	145	805
3	165	916

Source: *Timber-Mart South*

State and Zone	Average Price for 1977	
	$/MBF (Scribner)	$/MCF*
Texas		
1	140	777
2	143	794
3	-	-
Virginia		
1	90	500
2	109	605
3	134	744

APPENDIX B

Benefits and Costs of Sawmill Improvement, by Study, FY 1977

(1) Study number	(2) Annual production (MMBF)	(3) Original LRF	(4) 4 years raw material savings (MCF)	(5) Present value of savings ($)	(6) Study costs ($)	(5 - 6) Net present value ($)	(5 ÷ 6) B/C ratio
1	48	4.30	8,748.5	5,787,826	1,177	5,786,649	4,917:1
2	50	4.56	8,264.3	5,067,649	2,382	5,065,267	2,127:1
3	29	3.57	6,186.4	4,206,532	1,733	4,204,799	2,427:1
4	40	4.87	5,039.2	3,450,886	1,563	3,449,323	2,208:1
5	40	4.63	5,697.4	3,397,027	1,448	3,395,579	2,346:1
6	20	4.64	2,066.4	1,510,014	1,665	1,508,349	907:1
7	20	5.08	1,514.5	1,109,351	1,665	1,107,686	666:1
8	29	5.96	1,352.3	928,070	1,733	926,337	536:1
9	41	6.92	1,051.0	718,432	1,439	716,993	499:1
10	18	5.22	1,100.6	679,842	2,603	677,239	261:1
11	15	5.21	879.3	586,444	1,337	585,107	439:1
12	21	5.82	815.8	554,421	1,439	552,982	385:1
13	5	4.45	459.9	281,676	1,426	280,250	198:1
14	8	5.10	404.5	270,399	1,528	268,871	177:1
15	6	4.91	379.3	266,888	2,165	264,723	123:1
16	18	6.05	376.7	244,069	1,500	242,569	163:1
17	5	4.55	387.5	237,513	1,373	236,140	173:1
18	5	4.75	323.3	227,263	1,245	226,018	182:1

APPENDIX B (continued)

(1) Study number	(2) Annual Production (MMBF)	(3) Original LRF	(4) 4 years raw material savings (MCF)	(5) Present value of savings ($)	(6) Study costs ($)	(5 - 6) Net present value ($)	(5 ÷ 6) B/C ratio
19	12	5.71	322.7	218,000	1,432	216,568	152:1
20	5	4.76	320.8	192,615	1,232	191,383	156:1
21	4	4.54	262.2	184,065	1,260	182,805	146:1
22	4	4.56	257.0	180,530	1,246	179,284	145:1
23	9	5.58	246.1	170,933	1,964	168,969	87:1
24	4	4.68	230.3	161,950	1,282	160,668	126:1
25	4	4.96	230.0	141,615	1,473	140,142	96:1
26	4	4.97	197.7	121,847	1,372	120,475	89:1
27	4	4.99	193.3	119,110	1,387	117,723	86:1
28	10	5.85	162.9	115,097	1,880	113,217	61:1
29	5	5.33	158.7	96,307	1,279	95,028	75:1
30	2	4.66	93.9	57,243	1,523	55,720	38:1
31	5	5.55	102.9	56,222	1,491	54,731	38:1
32	6	5.84	52.4	33,527	1,230	32,297	27:1
33	4	5.63	48.0	30,645	1,408	29,237	22:1
34	6	5.82	48.1	27,370	1,184	26,186	23:1
35	5	6.10	-24.3	-14,498	2,074	-16,572	-7:1
36	4	6.12	-31.0	-16,955	1,211	-18,166	-14:1
37	8	6.26	-51.3	-30,368	1,390	-31,758	-22:1

APPENDIX B (continued)

(1) Study number	(2) Annual production (MMBF)	(3) Original LRF	(4) 4 years raw material savings (MCF)	(5) Present value of savings ($)	(6) Study costs ($)	(5 - 6) Net present value ($)	(5 ÷ 6) B/C ratio
38	8	6.33	-71.1	-31,515	1,833	-33,348	-17:1
39	3	6.38	-62.9	-32,096	1,231	-33,327	-26:1
40	4	6.26	-55.9	-32,262	1,455	-33,717	-22:1
41	4	6.50	-95.5	-56,299	1,367	-57,666	-41:1
42	8	6.41	-99.1	-56,281	2,335	-58,616	-24:1
43	5	7.24	-254.5	-152,522	1,406	-153,928	-108:1
44	5	7.10	-227.1	-155,381	2,109	-157,490	-74:1
45	12	6.86	-271.5	-161,109	2,103	-163,212	-77:1
Totals	572	245.58	46,729.7	30,692,092	70,578	30,621,514	435:1
Average per study	13	5.46	1,038.4	682,046	1,568	680,478	435:1